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Effect of Establishment Methods and Organic Nutrient Management Practices on Productivity and Profitability of Finger Millet (*Eleusine coracana* L.) in Lateritic Soils of Odisha

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was carried out during *kharif* seasons in 2020 and 2021 at Agronomy Main Research Farm, Department of Agronomy, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar to study effect of crop establishment method and organic nutrient management on finger millet ('Arjuna' variety). The experiment was laid out in a split plot design and replicated thrice. The treatments comprised of 2 methods of crop establishment *viz*.

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conventional method of line transplanting (20 cm x 10 cm) and system of finger millet intensification (25 cm X 25 cm) in main plot with application of 4 organic nutrient sources *viz.* farm yard manure *(*FYM) @ 100% recommended nitrogen dose (RDN), FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (top dressing) and FYM @ 25% RDN (basal) + *toria* oil cake @ 25% RDN (basal) + Vermicompost @ 50 % RDN (topdressing) allotted to sub plot in finger millet during *Kharif* season. System of finger millet intensification (SFMI) method of establishment resulted in superior yield attributes, grain yield (2,051 kg ha^{-1}), straw yield (2,901 kg ha^{-1}) and harvest index (41.42%) in finger millet than line transplanting. Yield attributes, grain yield (2,092 kg ha^{-1}), straw yield (2,889 kg ha^{-1}) and harvest index (42.00 %) were higher with the application of FYM @ 50% RDN (basal) + Vermicompost @ 50 % RDN (top dressing) in finger millet and was statistically similar with application of FYM @ 25% RDN (basal) + *toria* oil cake @ 25% RDN (basal) + Vermicompost @ 50 % RDN (top dressing). The benefit cost ratio was higher in SFMI and with the application of FYM @ 50% RDN (basal) + Vermicompost @ 50 % RDN (top dressing) to finger millet.

Keywords: SFMI; organic nutrient; yield attributes; grain yield; economics.

1. INTRODUCTION

Millets have been accorded a prominent position as super food in the present era. Under the changing scenario of global warming and climate change, cultivation of ecologically suitable hardy millets may be a wise alternative for optimum food and nutritional security. Finger millet (*Eleusine coracana* L.) is an important small millet ranking third in India in area and production having highest productivity. Out of the total minor millets produced, finger millet accounts for about 85% of production in India [1]. In Odisha, the area, production and productivity is 116.8 thousand hectares, 128.73 thousand tonnes and 1,102 kg/ha, respectively [2]. It is a versatile climate resilient crop with wide adaptability to adverse weather conditions with low input requirement, easy cultivation, free from major pests and diseases and drought tolerance which have made this crop an automatic choice in dry farming system. It is highly suitable for less input agriculture like organic agriculture [3]. It is nutritionally superior with high nutrient profile and is ideal for patients suffering from diabetes and digestive problems as the grains contain essential amino acid methionine having low glycemic index and no gluten. It is rich in protein, iron, calcium, phosphorous, fibre and vitamin content.The calcium content in this crop is higher than all cereals while the iodine content is said to be highest among all the food grains [4]. System of Rice Intensification (SRI) principle have been followed in finger millet which mainly emphasizes on: a) utilizing early growth and vigour of seedlings b) less competition for light and nutrients c) enhancing resource use efficiency (seeds, water, fertilizer, and pesticide) d) bring down over dependence on chemical fertilizers e) breaking soil anoxia condition f) promoting healthy root growth and increasing soil microbial activity and thereby enhancing soil organic matter content. Conversion of modern chemically intensive agriculture to a more sustainable form of agriculture like organic farming appears to be an option for maintaining the desirable agricultural production in future. Organic manures like FYM, vermicompost and *toria* oil cake play important role by supplying variety of nutrients, release them slowly and improve soil fertility [5]. Role of FYM is multidimensional ranging from building up of soil organic matter maintaining favourable soil physical and chemical properties and balanced supply of nutrients [6]. Use of vermicompost as a substitute for chemical fertilizer is advised by pioneers of organic farming [7]. Further, growing finger millet organically may insure nutritional food and farming security at the juncture of climate change.

2. MATERIALS AND METHODS

The field experiment was conducted at the Agronomy Main Research Farm, Department of Agronomy, College of Agriculture, Orissa University of Agriculture and Technology (OUAT), Bhubaneswar, Odisha with finger millet grown during *kharif* season *of* 2020 and 2021. The experimental site is situated between 20°15' N latitude, 85°52' E longitude and at an altitude of 25.9 m above the mean sea-level and about 64 km away of the Bay of Bengal, Odisha. The soil was sandy loam in texture, acidic in reaction (pH 4.64), low in organic carbon (4.24 g kg^{-1}, medium in available nitrogen (298.1 kg ha^{-1}), medium in available phosphorus (17.6 kg ha^{-1}) and low in available potassium (95 kg ha^{-1}). Total rainfall amounting to 989.1 mm (44 rainy days) and 1317.9 mm (59 rainy days) was received during

Kharif season of 2020 and 2021, respectively. The experiment was laid out in split plot design with three replications. The treatments comprised of 2 methods of plant establishment *viz*. M_1: conventional method of line transplanting (20 cm x 10 cm) and M_2: system of finger millet intensification (25 cm X 25 cm) in main plot with 4 organic nutrient sources *viz*. N_1: farm yard manure (FYM) @ 100% recommended dose of nitrogen (RDN), N_2: FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (basal), N_3: FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (top dressing), N_4: FYM @ 25% RDN (basal) + *toria* oil cake @ 25% RDN (basal) + Vermicompost @ 50 % RDN (top dressing) allotted to sub plot in finger millet. The RDN applied to finger millet was 60 kg ha^{-1}. In system of finger millet intensification (SFMI), square planting of 12 days old seedling was done @ one seedling $hill^{-1}$ .The organic formulation '*Jibamruta'* was sprayed uniformly to all the treatments at 21 days after transplanting (DAT) for controlling insect pests and diseases. Weeding operation was done in SFMI by using a cycle weeder.

Observations on yield attributes, grain yield and straw yield of finger millet were recorded at harvest. The collected data were analyzed statistically by standard analysis of variance technique for split plot design as suggested by Gomez and Gomez [8] and significant different between the treatments were compared with the critical difference at ± 5% probability by least significant difference.

3. RESULTS AND DISCUSSION

The pooled data of two years of *Kharif* season of 2020 and 2021 for yield attributes, yield and economics of finger millet are presented in Tables 1 to 3.

3.1 Effect of Establishment Methods on Yield Attributes, Yield and Economics of Finger Millet

Yield attributing characters i.e. earhead $hill^{-1}$, finger ear^{-1},spikelets $finger^{-1}$, grains $spikelet^{-1}$, finger length, 1000 grain weight of finger millet were higher in SFMI (7.9, 6.4, 88.6, 5.98, 7.90 cm and 3.37 g, respectively) than line transplanting. Less competition between plants due to wider space allowed the individual plants to develop massive root system and ultimately higher nutrient uptake. Better aeration at wider spacing resulted in healthy plant growth with more tillers [9]. These results were in conformity with the findings of Prakasha et al. [10].

The grain yield, straw yield and harvest index of finger millet were higher (2,051 kg ha^{-1}, 2,901 kg ha^{-1} and 41.42%, respectively) in SFMI than line transplanting. Grain yield and straw yield is the final outcome of a crop which generally relies on the development of yield attributes. Increase in growth attributes due to increased uptake of nitrogen and translocation of photosynthates from source to sink increased most of the yield attributing characters in SFMI. Similar findings were also reported by Naidu and Rao [11]; Narasimha Rao et al. [12]; Diva Karan [13]; Narasimha Murthy and Hegde [14]; PSI [15] and Rajesh [16] in finger millet.

The gross return (Rs.110721 ha^{-1} and Rs.118080 ha^{-1}), net return (Rs.53121 ha^{-1} and Rs.60480 ha^{-1}) and benefit:cost ratio (B: C) ratio (1.92 and 2.05) was higher in SFMI method of establishment in 2020- 21 and 2021-22, respectively.

3.2 Effect of Organic Nutrient Management on Yield Attributes, Yield and Economics ofFinger Millet

Yield attributing characters i.e. earhead $hill^{-1}$, finger ear^{-1}, spikelets $finger^{-1}$, grains spikelet-1, finger length, 1000 grain weight of finger millet were higher (6.5, 6.5, 71.5, 5.84,7.86 and 3.36 g, respectively) when FYM @ 50% RDN (basal) + Vermicompost @ 50 % RDN (top dressing) was applied to finger millet but was statistically at par with application of FYM @ 25% RDN (basal) + toria oil cake @ 25% RDN (basal) + Vermicompost @ 50 % RDN (top dressing). The higher yield attributes might be due to higher macro and micro nutrient content of vermicompost which enabled continuous and steady release of nutrients. FYM application also increased the nutrient uptake which might have helped in better tillering, ear length, grain filling, number of grains $earhead^{-1}$ [17,18].

The grain yield, straw yield and harvest index (%) of finger millet were also higher (2,092 kg ha^{-1}, 2,889 kg ha-1 and 42.00 %, respectively) when FYM @ 50% RDN (basal) + Vermicompost @ 50 % RDN (top dressing) was applied to finger millet but was statistically at par with application of FYM @ 25% RDN (basal) + *toria* oil cake @ 25% RDN (basal) + Vermicompost @ 50% RDN (top dressing). Balanced combination of organic sources is indispensable to supplement nutrients

Table 1. Yield attributing characters of finger millet as influenced by organic nutrient management practices

Treatment	Yield attributes																	
	Ear head hill^{-1}			Fingers ear^{-1}			Spikelets finger^{-1}			Grain spikelet^{-1}			Finger length			1000 grain weight (g)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Establishment method (M) in finger millet																		
M1: Line transplanting	2.9	3.2	3.1	4.9	5.1	5.0	39.2	41.4	40.2	4.40	4.41	4.41	7.03	7.08	7.06	3.14	3.15	3.15
M2: SFMI	7.8	8.0	7.9	6.4	6.3	6.4	92.6	91.8	88.6	5.90	6.05	5.98	7.96	7.83	7.90	3.37	3.36	3.37
S.E.m(**±**)	1.4	1.4	1.0	0.27	0.2	0.16	1.18	1.7	1.01	0.40	0.43	0.29	0.23	0.24	0.17	0.06	0.06	0.04
CD(0.05)	4.1	4.3	2.8	1	1.1	0.5	3.6	3.2	2.9	1.2	1.3	0.8	0.7	0.7	0.5	0.2	0.2	0.1
Nutrient management (N) in finger millet																		
N1: FYM @ 100% RDN (basal)	4.3	4.5	4.4	5.0	5.1	5.1	61.8	62.0	61.9	4.67	4.675	4.67	7.11	6.98	7.05	3.11	3.13	3.12
N2: FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (basal)	4.9	5.0	5.0	5.3	5.4	5.4	62.9	63.5	63.2	4.97	4.94	4.95	7.4	7.32	7.36	3.25	3.24	3.25
N3: FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (topdressing)	6.3	6.6	6.5	6.4	6.5	6.5	71.0	71.9	71.5	5.74	5.93	5.84	7.84	7.88	7.86	3.36	3.35	3.36
N4: FYM @ 25% (basal) + *toria* oilcake@ 25% RDN (basal) + Vermicompost @ 50% RDN (top dressing)	5.9	6.3	6.1	5.9	5.8	5.9	67.9	69.1	68.5	5.38	5.38	5.38	7.64	7.66	7.65	3.30	3.29	3.29
S. Em(±)	0.46	0.42	0.31	0.39	0.26	0.22	2.24	2.41	1.64	0.24	0.3	0.19	0.13	0.14	0.09	0.03	0.03	0.02
CD(0.05)	1.4	1.3	0.9	0.9	0.8	0.7	6.8	7.3	4.8	0.7	0.9	0.5	0.4	0.4	0.3	0.1	0.1	0.06
M x N																		
S.Em(±)	1.98	1.94	1.38	0.78	0.58	0.48	3.51	4.21	2.72	0.76	0.84	0.56	0.47	0.48	0.33	0.16	0.16	0.11
CD (0.05)	5.9	5.8	4.0	2.36	1.75	1.38	10.7	12.7	7.86	2.3	2.5	1.6	1.42	1.45	0.96	0.48	0.48	0.32

Table 2. Grain yield, straw yield and harvest index of finger millet as influenced by establishment method and organic nutrientmanagement

Treatment	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest index (%)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Establishment method (M) in finger millet									
M1: Line transplanting	1642	1714	1678	2483	2579	2531	39.81	39.93	39.87
M2: SFMI	2007	2095	2051	2844	2958	2901	41.37	41.46	41.42
SEm±	46.60	53.30	35.32	57.10	58.89	41.01	0.46	0.46	0.33
CD(0.05)	141.2	161.5	102.3	173.1	178.4	118.8	1.4	1.4	0.9
Nutrient management (N) in finger millet									
N1: FYM @ 100% RDN (basal)	1510	1610	1560	2504	2562	2533	37.62	38.59	38.10
N2: FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (basal)	1800	1840	1820	2565	2712	2638.5	41.24	40.42	40.83
N3: FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (top dressing)	2028	2157	2092	2812	2967	2889.5	41.90	42.10	42.00
N4: FYM @ 25% (basal) + *toria* oilcake @ 25% RDN (basal) Vermicompost @50%RDN(top dressing)	1961	2011	1986	2773	2833	2803	41.42	41.52	41.47
S.Em(±)	65.90	75.37	49.95	80.73	82.57	57.74	0.20	0.20	0.14
CD (0.05)	199.7	228.4	144.6	244.8	252.2	167.2	0.6	0.6	0.4
M x N									
S.Em (±)	126.10	139.60	93.95	148.30	152.20	106.25	0.78	0.78	0.55
CD (0.05)	382.0	422.9	270.6	449.3	461.1	306.0	2.4	2.4	1.6

Table 3. Economics of finger millet as influenced by establishment method and organic nutrient management practices

Treatment	Gross return(Rs. ha^{-1})		Net return(Rs. ha^{-1})		B-C ratio	
	2020	2021	2020	2021	2020	2021
Establishment method (M) in finger millet						
M1: Line transplanting	97158	103051	34433	40326	1.55	1.64
M2: SFMI	110721	118080	53121	60480	1.92	2.05
Nutrient management (N) in finger millet						
N1: FYM @ 100% RDN (basal)	90088	96954	32138	39004	1.55	1.67
N2: FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (basal)	103175	107917	42475	47217	1.70	1.78
N3: FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (top dressing)	112573	121594	51873	60474	1.85	2.00
N4: FYM @ 25% (basal) + *toria* oilcake @ 25% RDN (basal) + Vermicompost @ 50% RDN(top dressing)	109947	115796	48047	54316	1.78	1.88

in accordance with the demand of plants for ensuring higher production and productivity without having deleterious effect on soil health. Top dressing of vermicompost ensured continuous availability of nutrients throughout the crop growth stages due to steady transformation, mineralization, solubilisation, decomposition of minerals and nutrients that might helped in ensuring superior yield attributing characters and yield. Supply of nitrogen and other nutrients at right time and quantity enable the plants to assimilate sufficient photosynthetic products and thus increased yield attributes and yield of the crop and also bring an improvement towards physical properties of soil and thereby improving nutrient and water holding capacity [13]. Highest gross return (Rs.112573 and 121595 ha^{-1}), net return (Rs.51873 and Rs 60474 ha^{-1}) and B:C ratio (1.85 and 2.00) were recorded with the treatment receiving FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (top dressing) during 2020-21 and 2021-22, respectively.

3.3 Interaction

It is observed that interaction of SFMI with nutrient management by application of FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (top dressing) produced maximum numbers of yield attributes and ultimately resulted in higher yield. However, it was at par with application of FYM @ 25% RDN (basal) + *toria* oil cake @ 25% RDN (basal) + Vermicompost @ 50 % RDN (top dressing). Wider spacing with organic nutrient management resulted in less competition between plants for solar radiation, space and increased supply of nutrients and efficient utilization helps in better growth and yield [9].

4. CONCLUSION

The study indicates that SFMI method of crop establishment resulted in superior yield attributes and yield of finger millet over the conventional method of line transplanting. Application of FYM @ 50% RDN as basal + Vermicompost @ 50% RDN as top dressing to finger millet resulted in higher yield attributing characters and yield in finger millet and this was statistically similar with the application of FYM @ 25% RDN (basal) + *toria* oil cake @ 25% RDN (basal) + Vermicompost @ 50% RDN (top dressing) to finger millet. The gross return, net return and B: C ratio was higher in FYM @ 50% RDN as basal + Vermicompost @ 50% RDN as top dressing. So considering the productivity and profitability, farmers can adopt SFMI with the application of FYM @ 50% RDN as basal (6.55 t/ha) + Vermicompost @ 50% RDN as top dressing (1.62 t/ha) in finger millet in lateritic soils of Odisha.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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